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DESCRIPTION

DATA TRANSMISSION SYSTEM AND DATA TRANSMISSION METHOD

5 Technical Field

The present invention relates to a data transmission system composed of a communication terminal apparatus and base station apparatus in a mobile communication system and a method of data transmission between these
10 apparatuses.

Background Art

Heretofore, a data transmission system and data transmission method of this kind have been disclosed in
15 Patent Publication No. 1647396.

FIG.1 is a block diagram showing the configuration of a conventional data transmission system. The data transmission system shown in FIG.1 comprises a transmitting side apparatus 10 and a receiving side
20 apparatus 60.

The transmitting side apparatus 10 comprises a buffer 11, transmit frame creation section 12, modulator 13, transmit radio section 14, antenna 15, antenna duplexer 16, receive radio section 17, demodulator 18,
25 and separator 19.

The receiving side apparatus 60 comprises an antenna 61, antenna duplexer 62, receive radio section 63,

demodulator 64, data holding section 65, error detection section 66, transmit frame creation section 67, modulator 68, and transmit radio section 69.

With this kind of configuration, first, in the
5 transmitting side apparatus 10, transmit data is stored in the buffer 11, this stored transmit data is framed by the transmit frame creation section 12, and this transmit frame signal is output to the modulator 13.

After undergoing modulation processing by the
10 modulator 13, the transmit frame signal undergoes predetermined radio processing such as up-conversion by the transmit radio section 14, and after passing via the antenna duplexer 16, is transmitted as a radio signal from the antenna 15.

15 Then, in the receiving side apparatus 60, a signal received by the antenna 61 is output via the antenna duplexer 62 to the receive radio section 63, where it undergoes predetermined radio processing such as down-conversion, and the resulting signal is output to
20 the demodulator 64.

The received signal is demodulated by the demodulator 64, and this demodulated receive data is held in the data holding section 65 and output to the error detection section 66. The error detection section 66
25 performs error detection on the receive data. If an error is detected, a signal (hereinafter referred to as "NACK signal") requesting retransmission is output from the

error detection section 66 to the transmit frame creation section 67.

In the transmit frame creation section 67, framing is performed that multiplexes the NACK signal with
5 transmit data, and this transmit frame signal is output to the modulator 68. This transmit frame signal is modulated by the modulator 68, and after undergoing predetermined radio processing by the transmit radio section 69, is transmitted as a radio signal from the
10 antenna 61 via the antenna duplexer 62.

This transmit signal is received by the antenna 15 of the transmitting side apparatus 10, output via the antenna duplexer 16 to the receive radio section 17 where it undergoes predetermined radio processing, and then
15 demodulated by the demodulator 18 and separated into receive data and a NACK signal by the separator 19. The receive data is output to latter-stage receive processing circuitry (not shown), and the NACK signal is output to the buffer 11, whereby the data previously transmitted
20 from the buffer 11 is retransmitted.

This retransmitted data is received in the receiving side apparatus 60 in the same way as described above, and is held combined with the previous receive data in the data holding section 65. This held combined data
25 undergoes error detection by the error detection section 66.

As described above, if an error is detected, a NACK

signal is output to the transmit frame creation section 67. If, on the other hand, no error is detected, a transmission request signal (hereinafter referred to as "ACK signal") requesting transmission of the next data from the transmitting side apparatus 10 is output to the transmit frame creation section 67.

The above-described series of operations is repeated until an ACK signal is obtained in this way. When an ACK signal is obtained, the data in the data holding section 65 is considered to be receive data, and is output to latter-stage receive processing circuitry (not shown). Following this output, that receive data is eliminated from the data holding section 65.

When an ACK signal is input to the transmit frame creation section 67, the transmit frame creation section 67 performs framing that multiplexes the ACK signal with transmit data. This transmit frame signal is transmitted to the transmitting side apparatus 10 as described above.

In the transmitting side apparatus 10, the received ACK signal is output to the buffer 11, and the data for which that ACK signal was obtained is eliminated from the buffer 11. Then, transmission of the next data begins.

As described above, in a conventional data transmission system, receive data error detection is carried out by the receiving side apparatus, and if an error is detected a retransmission request is made to

the transmitting side apparatus. In response to this, an operation to retransmit the same data is repeated, so that eventually there is no data error in the receiving side apparatus.

- 5 However, with conventional apparatuses, in response to a retransmission request from the receiving side, an operation that performs retransmission on the transmitting side is simply repeated until there is no data error on the receiving side, and there is thus a
10 problem in that, if the retransmitted data is not appropriate, the number of retransmissions will be large and transmission efficiency will degrade.

Disclosure of Invention

- 15 It is an object of the present invention to provide a data transmission system and data transmission method that enable the number of data retransmissions during transmission and reception to be decreased, thereby enabling transmission efficiency to be improved.

- 20 This object is achieved by noting that receive data can be combined, and as long as the result of combination meets a predetermined quality, receive data can be demodulated; and detecting the capacity necessary for demodulation, and performing scheduling at the time of
25 retransmission so that data is retransmitted at the capacity necessary for demodulation.

Brief Description of Drawings

FIG.1 is a block diagram showing the configuration of a conventional data transmission system;

5 FIG.2 is a block diagram showing the configuration of a data transmission system according to Embodiment 1 of the present invention;

FIG.3 is a drawing showing a reception quality transmission method for a data transmission system
10 according to Embodiment 1 of the present invention; and

FIG.4 is a block diagram showing the configuration of a data transmission system according to Embodiment 2 of the present invention.

15 Best Mode for Carrying out the Invention

With reference now to the accompanying drawings, embodiments of the present invention will be explained in detail below.

20 (Embodiment 1)

FIG.2 is a block diagram showing the configuration of a data transmission system according to Embodiment 1 of the present invention. The data transmission system shown in FIG.2 comprises a transmitting side apparatus
25 100 and a receiving side apparatus 150.

The transmitting side apparatus 100 comprises a buffer 101, transmit frame creation section 102,

modulator 103, transmit radio section 104, antenna 105, antenna duplexer 106, receive radio section 107, demodulator 108, separator 109, and scheduling section 110.

5 The receiving side apparatus 150 comprises an antenna 151, antenna duplexer 152, receive radio section 153, demodulator 154, data holding section 155, error detection section 156, reception quality measurement section 157, transmit frame creation section 158,
10 modulator 159, and transmit radio section 160.

The flow of data transmitted and received between the transmitting side apparatus 100 and receiving side apparatus 150 will be described below.

First, in the transmitting side apparatus 100,
15 transmit data is stored in the buffer 101, this stored transmit data is framed by the transmit frame creation section 102, and this transmit frame signal is output to the modulator 103.

After undergoing modulation processing by the
20 modulator 103, the transmit frame signal undergoes predetermined radio processing such as up-conversion by the transmit radio section 104, and after passing via the antenna duplexer 106, is transmitted as a radio signal from the antenna 105.

25 Then, in the receiving side apparatus 150, a signal received by the antenna 151 is output via the antenna duplexer 152 to the receive radio section 153. In the

receive radio section 153 predetermined radio processing such as down-conversion is carried out on the radio frequency received signal, and a baseband received signal is output to the reception quality measurement section 5 157 and demodulator 154.

In the reception quality measurement section 157, the received signal quality is determined by measurement of the SIR (signal to interference ratio), received field strength, or the like, and a signal indicating this 10 received signal quality (hereinafter referred to as "reception quality signal") is output to the transmit frame creation section 158.

The received signal is demodulated by the demodulator 154, and this demodulated receive data is 15 held in the data holding section 155 and output to the error detection section 156. The error detection section 156 performs error detection on the receive data. If an error is detected, a NACK signal is output from the error detection section 156 to the transmit frame creation 20 section 158.

In the transmit frame creation section 158, framing is performed that multiplexes the reception quality signal and NACK signal with transmit data, and the framed signal, which is a transmit frame signal, is output to 25 the modulator 159.

The transmit frame signal is modulated by the modulator 159, and after undergoing predetermined radio

processing by the transmit radio section 160, is transmitted as a radio signal from the antenna 151 via the antenna duplexer 152.

5 This transmit signal is received by the antenna 105 of the transmitting side apparatus 100, output via the antenna duplexer 106 to the receive radio section 107 where it undergoes predetermined radio processing, and then demodulated by the demodulator 108 and output to the separator 109.

10 In the separator 109, the demodulated data is separated into three components: receive data, a NACK signal, and a reception quality signal. The receive data is output to latter-stage receive processing circuitry (not shown), and the NACK signal and reception quality
15 signal are output to the scheduling section 110.

In the scheduling section 110, a retransmission request is recognized from the NACK signal, radio resources are assigned according to the traffic conditions at the time of retransmission, scheduling is
20 determined according to these radio resources and the reception quality signal, and retransmission is carried out using this scheduling.

Here, the scheduling section 110 finds the maximum transmission capacity of data that can be transmitted
25 from the traffic volume at the time of retransmission, and if the capacity necessary for demodulation is greater than this maximum transmission capacity, performs

scheduling so that data is retransmitted at the maximum transmission capacity.

Assume, for example, that 30% of the capacity necessary for demodulation is received in the first transmission, and the reception quality signal is
5 information indicating that a further 70% capacity is necessary for demodulation. In this case, if there is room in the traffic, the scheduling section 110 performs scheduling so that data is transmitted at 70% capacity
10 at one time.

However, if there is no room in the traffic, and, for example, data can only be transmitted at 30% capacity, the scheduling section 110 will retransmit data at 30% capacity. In this case, since only 60% of the capacity
15 necessary for demodulation has been received at that point, a NACK signal is again returned to have 40% retransmitted. If, at this time, data can only be transmitted at 30%, retransmission is performed again at 30% capacity. In this way, 90% of the necessary capacity is received by
20 the receiving side, and therefore 10% capacity retransmission is requested by the next NACK signal. So 10% retransmission is performed this time. Thus, in response to a request that exceeds the maximum capacity, scheduling is performed so that data is retransmitted
25 at the maximum capacity at that point. In this case, the number of data retransmissions is three.

Also, scheduling need not be limited to being determined according to the number of retransmissions in this way, but may also be determined taking account of a transmission method other than number of retransmissions. An example of another transmission method is to transmit data according to any one or a combination of spreading factor, transmission rate, modulation method, coding rate, beam width, and array directivity. That is to say, as well as the number of retransmissions being determined according to the current traffic, the other transmission method is changed, and scheduling is determined according to the transmission method after this change.

A change of spreading factor is carried out for the transmit frame creation section 102 and modulator 103, a change of transmission rate for the transmit frame creation section 102, a change of modulation method for the transmit frame creation section 102 and modulator 103, and a change of code rate for the transmit frame creation section 102. Changes of beam width and array directivity are carried out when the antenna 105 has an array configuration.

Based on scheduling determined in this way, data transmitted last time in the buffer 101 is retransmitted at the capacity necessary for demodulation.

This retransmitted data is received by the receiving side apparatus 150 in the same way as described above,

and is combined with the previous receive data and held in the data holding section 155. This held combined data undergoes error detection by the error detection section 156.

5 As described above, if an error is detected, a NACK signal is output to the transmit frame creation section 158. If, on the other hand, no error is detected, an ACK signal requesting transmission of the next data from the transmitting side apparatus 100 is output to the transmit
10 frame creation section 158.

 The above-described series of operations is repeated until an ACK signal is obtained in this way. When an ACK signal is obtained, the data in the data holding section 155 is considered to be receive data, and is output
15 to latter-stage receive processing circuitry (not shown). Following this output, that receive data is eliminated from the data holding section 155.

 When an ACK signal is input to the transmit frame creation section 158, the transmit frame creation section
20 158 performs framing that multiplexes the ACK signal with transmit data. This transmit frame signal is transmitted to the transmitting side apparatus 100 as described above.

 In the transmitting side apparatus 100, the received ACK signal is sent to the scheduling section 110. When
25 the ACK signal is input to the scheduling section 110, the scheduling section 110 performs control to eliminate data for which that ACK signal was obtained from the buffer

101, and starts transmission control for the next data.
At the same time, radio resources to be used for
transmission are assigned according to the traffic
conditions at that start time, scheduling is determined
5 according to the radio resources, and transmission of
the next data is started in accordance with this
scheduling.

Thus, the receiving side apparatus performs receive
data error detection, and when an error is detected
10 transmits a retransmission request signal and reception
quality signal, and the transmitting side apparatus
identifies the capacity necessary for demodulation by
the receiving side apparatus from the reception quality
signal when the retransmission request signal is received,
15 and retransmits data at this capacity necessary for
demodulation.

By this means, it is possible to reduce the number
of data retransmissions during transmission and reception,
and improve transmission efficiency. In other words, it
20 is possible to prevent the degradation in transmission
efficiency due to the large number of retransmissions
resulting from simply repeating retransmissions until
there is no data error on the receiving side in the
conventional way.

25 Also, when data is retransmitted, the transmitting
side apparatus finds the maximum transmission capacity
at which transmission is possible from the traffic volume

at that time, and if the capacity necessary for demodulation is greater than this maximum transmission capacity, retransmits data at the maximum transmission capacity.

5 By this means, data can be retransmitted efficiently even if the capacity necessary for demodulation is greater than the transmissible maximum transmission capacity at the time of retransmission, and transmission efficiency can be improved.

10 Moreover, when data is retransmitted, in the transmitting side apparatus the scheduling section 110 assigns radio resources comprising various radio communication functions according to traffic conditions at that time so that data can be retransmitted at the
15 greatest possible capacity.

 By this means, a transmission method that includes number of transmissions can be changed optimally within radio resources, thereby enabling the number of data retransmissions during transmission and reception to be
20 reduced, and transmission efficiency to be improved.

 Furthermore, in the transmitting side apparatus 100, the scheduling section 110 may preassign radio resources to be used for transmission according to traffic conditions before transmitting the first data, and
25 transmit according to these radio resources. In this case, when the receiving side apparatus 150 sends back a NACK signal and reception quality signal, the scheduling

section 110 determines scheduling according to the
aforementioned preassigned radio resources, and applies
this scheduling until the end of retransmissions.

Also, assignment of radio resources used in
5 transmission according to traffic conditions may be
performed once for every particular chunk of data—that
is, every certain number of transmissions of packet data.
Moreover, it is also possible to perform radio resource
assignment only at the time of initial data transmission
10 when transmission of all packet data is performed.

By these means, it is possible to eliminate
processing for deciding on radio resources when
retransmitting, and to reduce overall apparatus
processing. Furthermore, since individual channels can
15 be extended, scheduling can be carried out in an
unrestricted fashion without considering other users.

Also, it is possible to perform reception quality
measurement only the first time an error is detected.
In this case, the first reception quality signal sent
20 to the scheduling section 110 is stored, and thereafter,
that stored reception quality signal is used as it is
until the end of retransmissions. In addition, reception
quality measurement may be performed at a rate of once
per predetermined number of times. In this case, a
25 reception quality signal sent to the scheduling section
110 is stored, and thereafter, that stored reception
quality signal is sequentially updated for use.

By this means, reception quality measurement by the receiving side apparatus can be reduced, enabling lower receiving side apparatus power consumption to be achieved. This is especially useful when the receiving side
5 apparatus is a communication terminal apparatus.

Furthermore, when determining scheduling at the time of data transmission, a configuration may be used whereby reception quality for the previous data is referenced. That is to say, in the transmitting side
10 apparatus 100 the scheduling section 110 stores the reception quality signal for the previous data. When an ACK signal is sent and transmission of the previous data ends, transmission of the next data is started. At this time the scheduling section 110 assigns radio resources
15 to be used for transmission according to the stored reception quality signal and the traffic conditions.

For example, if reception quality is good and retransmission is not necessary, transmission is performed with radio resources reduced to a level at which
20 demodulation can be performed at one time. To be more specific, assuming that in initial data transmission the receiving side apparatus 150 receives at 120% of the capacity necessary for demodulation, in transmission of the next data, transmission will be performed at 10/12
25 of the capacity of the previous time so that data is received at 100% of the capacity necessary for demodulation.

On the other hand, if reception quality is poor, transmission is performed with radio resources extended to a level at which demodulation can be performed at one time. For example, assuming that in initial data
5 transmission data is received at 30% of the capacity necessary for demodulation, and the remaining 70% capacity transmission is performed by retransmission, enabling demodulation to be achieved, in transmission of the next data, transmission will be performed at 10/3
10 of the capacity of the previous time so that data is received at 100% of the capacity necessary for demodulation. However, this applies only to the case where 100% transmission is permitted within the radio resources. If, for example, transmission within the
15 radio resources is only permitted at up to 80% of the capacity necessary for demodulation, it will be determined that the next data is to be sent at 80%, followed by retransmission at 20%.

By using the previous reception quality signal in
20 initial data transmission in this way, it is possible to transmit data with an optimal transmission method including number of retransmissions even in initial transmission.

In the above description, the transmit frame
25 creation section 158 performs framing by independently multiplexing the reception quality signal and the NACK signal/ACK signal with transmit data. However, the

present invention is not limited to this, and it is also possible for the transmit frame creation section 158 to perform processing so that the NACK signal has information indicating reception quality, and to perform framing by
 5 multiplexing the post-processing NACK signal/ACK signal with transmit data.

For example, there may be three kinds of NACK signal representation—"N1", "N2", and "N3"—according to the reception quality, with representation as four states
 10 (two bits) together with the ACK signal "AC". Then the three kinds of NACK signal will be differentiated as follows: "N1" when reception quality is comparatively good and demodulation will be possible on reception of a signal of a little more capacity (for example, 0 to
 15 25%); "N2" when reception quality is good and a signal of a certain level of capacity (for example, 25 to 50%) is necessary for demodulation; and "N3" when reception quality is poor and a signal of considerable capacity (for example, 50% or more) is necessary for demodulation.

20 FIG.3 is a drawing showing the reception quality transmission method in this case. FIG.3 shows transmit packets A to E, reception quality at the time of transmission of those packets, and a NACK signal/ACK signal represented by four states based on reception
 25 results. The width of a transmit packet indicated by a rectangle shows the size of the capacity.

FIG.3 shows the case where an error is detected in

packets B and E and the other packets are received correctly. The propagation environment when packet B is transmitted is comparatively good, and the propagation environment when packet E is transmitted is poor.

5 In the case shown in FIG.3, the receiving side apparatus transmits "N1" to the transmitting side apparatus to request retransmission of packet B. The transmitting side apparatus determines that a further 25% capacity is necessary for demodulation, and
10 retransmits packet B (B_{R1}).

 The receiving side apparatus also transmits "N3" to the transmitting side apparatus to request retransmission of packet E. The transmitting side apparatus determines that a further 75% capacity is
15 necessary for demodulation, and retransmits packet E (E_{R1}).

 It is herein assumed that the receiving side apparatus receives packet E_{R1} but is not able to demodulate the packet because the capacity is not quite sufficient.
20 The receiving side apparatus then transmits "N1" to request retransmission of packet E once again. The transmitting side apparatus determines that a further 25% capacity is necessary for demodulation, and retransmits packet E (E_{R2}).

25 If framing is performed by multiplexing with transmit data a NACK signal or ACK signal that has information indicating reception quality in this way,

it is possible to reduce the transmission of signals other than transmit data compared with the case where a reception quality signal and NACK signal/ACK signal are simply multiplexed with transmit data, and thus to improve transmission efficiency.

Also, if the number of kinds of NACK signal is a power of 2 - 1, the number of kinds of signal together with the ACK signal is a power of 2, and therefore this is convenient for performing binary digital transmission.

(Embodiment 2)

FIG.4 is a block diagram showing the configuration of a data transmission system according to Embodiment 2 of the present invention. Parts in the data transmission system shown in FIG.4 identical to those in FIG.2 are assigned the same codes as in FIG.2 and their detailed explanations are omitted.

The data transmission system shown in FIG.4 differs from that in FIG.2 in having a separator 251 and scheduling section 252 added to the receiving side apparatus 250.

With this kind of configuration, first, in the transmitting side apparatus 100 the scheduling section 110 assigns radio resources to be used for transmission according to the traffic conditions before transmit data is transmitted, and outputs a radio resource signal indicating information on these radio resources to the transmit frame creation section 102.

In the transmit frame creation section 102, framing is performed that multiplexes the radio resource signal with transmit data, and this transmit frame signal is transmitted.

5 This transmit frame signal is received by the receiving side apparatus 250, and after being demodulated by the demodulator 154, is separated into data and a radio resourcesignal by the separator 251. This separated data is held by the data holding section 155 and output to
10 the error detection section 156, and the radio resource signal is output to the scheduling section 252.

In the scheduling section 252, when a NACK signal is input in the event of error detection, scheduling within assigned radio resources is determined based on the
15 reception quality signal and radio resource signal, and a scheduling signal indicating the scheduling result and a NACK signal are output to the transmit frame creation section 158.

In the transmit frame creation section 158, framing
20 is performed that multiplexes the scheduling signal and NACK signal with transmit data, and this transmit frame signal is transmitted.

This transmit frame signal is received by the transmitting side apparatus 100, and is separated into
25 three components by the separator 109: data, a NACK signal, and a scheduling signal.

The NACK signal and scheduling signal are output

to the scheduling section 110, where retransmission control is performed according to the scheduling indicated by the scheduling signal.

5 Data retransmitted in accordance with this control is combined with the previous data and held in the data holding section 155, and this combined data undergoes error detection by the error detection section 156. Thereafter, the above-described series of operations is repeated until an ACK signal is obtained.

10 When an ACK signal is obtained, the data in the data holding section 155 is considered to be receive data, and is output to latter-stage receive processing circuitry (not shown). Following this output, that receive data is eliminated from the data holding section
15 155.

The ACK signal is input to the transmit frame creation section 158 where framing is performed that multiplexes the ACK signal with transmit data, and the resulting signal is transmitted to the transmitting side
20 apparatus 100.

In the transmitting side apparatus 100, the received ACK signal is sent to the scheduling section 110 where control is performed to eliminate data for which the ACK signal was obtained from the buffer 101, and transmission
25 control for the next data is started.

At the same time, in the scheduling section 110 radio resources to be used for transmission are assigned

according to the traffic conditions at that start time,
a radio resource signal indicating information on those
radio resources is multiplexed with the next output to
form a frame by the transmit frame creation section 102,
5 and this transmit frame signal is transmitted.

Thus the transmitting side apparatus 100 preassigns
radio resources to be used for transmission based on the
traffic conditions before data transmission, and
transmits information on these radio resources. The
10 receiving side apparatus 250 finds the capacity necessary
for demodulation from the reception quality when a receive
data error is detected, and determines scheduling
information for retransmitting data within the radio
resources indicated by the above-mentioned information.
15 The transmitting side apparatus 100 then retransmits data
based on that scheduling information.

By this means, it is sufficient for data necessary
for demodulation found on the receiving side to be
retransmitted from the transmitting side, enabling the
20 number of data retransmissions during transmission and
reception to be reduced and transmission efficiency to
be improved.

As is clear from the above descriptions, according
to the present invention the number of data
25 retransmissions during transmission and reception can
be reduced and transmission efficiency can be improved
by detecting the capacity necessary for demodulation,

and, at the time of retransmission, performing scheduling and retransmitting data at the capacity necessary for demodulation.

This application is based on Japanese Patent Application No. 2000-150507 filed on May 22, 2000, and Japanese Patent Application No. 2001-078466 filed on March 19, 2001, entire content of which is expressly incorporated by reference herein.

10 Industrial Applicability

The present invention is suitable for use in a communication terminal apparatus and base station apparatus in a mobile communication system.